

Draft Genome Sequence of *Rhodococcus* sp. Strain 311R

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Here, we report the draft genome sequence of *Rhodococcus* sp. strain 311R, which was isolated from a site contaminated with alkanes and aromatic compounds. Strain 311R shares 90% of the genome of *Rhodococcus erythropolis* SK121, which is the closest related bacteria.

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Members of the genus *Rhodococcus* are aerobic, Gram-positive, nonmotile, nonsporulating, slow-growing, high-GC, and nocardioform actinomycetes (1). *Rhodococcus* species show remarkable metabolic versatility, including the ability to degrade hexane (2), benzene (3), polychlorinated biphenyl (4), polybrominated diphenyl ethers (5), and aromatic alcohols (6), and they are able to bioconvert a diverse range of organic compounds into triacylglycerols for use as biofuels (7). Moreover, *Rhodococcus equi* has been described as a pathogen responsible for bronchopneumonia in young foals (8, 9), and recently, *Rhodococcus* sp. strain BG43, closely related to *Rhodococcus erythropolis*, has been described as a degrader of the *Pseudomonas* quinolone signal, a quorum-sensing signal molecule employed by the opportunistic pathogen *Pseudomonas aeruginosa* (10).

Here, we present the draft genome sequence of *Rhodococcus* sp. strain 311R (taxon identification [ID] 1617904), isolated from soil of a hydrocarbon-contaminated environment (11–13) and capable of growing in benzene, decane, phenol, or anthranilate as a sole carbon source.

The genome was sequenced using the Illumina MiSeq platform, which generated paired-end reads sequences of 250 bp, and assembled using Edena (14, 15), producing 128 contigs with a total genome size of 6,343,721 bp (62.57% G+C content; N_{50} , 88.31 Kbp; mean, 49.22 Kb), with an average of 43.7-fold coverage. Automatic annotation was performed using the RAST server version 4.0 (16), generating 6,091 features potentially assigned to protein-coding genes (open reading frames [ORFs]).

A comparison between the draft genome of 311R and the 12 genomes/draft genomes of *Rhodococcus* sp. DK17 (17), *Rhodococcus* sp. JVH1 (18), *R. jostii* RHA1 (19), *R. erythropolis* PR4 (20), *R. erythropolis* SK121 (BioProject PRJNA55853), *R. erythropolis* CCM2595 (21), *R. erythropolis* R138 (22), *R. opacus* B4 (3), *R. opacus* PD630 (7), *R. equi* 103S (8), *R. pyridinivorans* SB3094 (23), and *Rhodococcus* sp. Chr-9 (24) showed that the closest strain to 311R is *R. erythropolis* SK121, with an average 90.5% (amino acid sequence) ORF similarity. The two strains share 5,445 ORFs, with >80% similarity (88% of the whole genome), and 354 ORFs observed in the genome of the strain 311R are absent from the ge-

nome of strain SK121, indicating that these strains belong to different species.

Nucleotide sequence accession number. This draft genome sequencing project has been deposited in the European Nucleotide Archive under the accession number [CFHW00000000](https://www.ebi.ac.uk/ena/submit/data).

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REFERENCES

- Bell KS, Philp JC, Aw DW, Christofi N. 1998. The genus *Rhodococcus*. *J Appl Microbiol* 85:195–210. [http://dx.doi.org/10.1046/j.1365-2672.1998.00525.x](https://doi.org/10.1046/j.1365-2672.1998.00525.x).
- Lee EH, Kim J, Cho KS, Ahn YG, Hwang GS. 2010. Degradation of hexane and other recalcitrant hydrocarbons by a novel isolate, *Rhodococcus* sp. EH831. *Environ Sci Pollut Res Int* 17:64–77. [http://dx.doi.org/10.1007/s11356-009-0238-x](https://doi.org/10.1007/s11356-009-0238-x).
- Na KS, Kuroda A, Takiguchi N, Ikeda T, Ohtake H, Kato J. 2005. Isolation and characterization of benzene-tolerant *Rhodococcus opacus* strains. *J Biosci Bioeng* 99:378–382. [http://dx.doi.org/10.1263/jbb.99.378](https://doi.org/10.1263/jbb.99.378).
- Takeda H, Shimodaira J, Yukawa K, Hara N, Kasai D, Miyauchi K, Masai E, Fukuda M. 2010. Dual two-component regulatory systems are involved in aromatic compound degradation in a polychlorinated-biphenyl degrader, *Rhodococcus jostii* RHA1. *J Bacteriol* 192:4741–4751. [http://dx.doi.org/10.1128/JB.00429-10](https://doi.org/10.1128/JB.00429-10).
- Robrock KR, Mohn WW, Eltis LD, Alvarez-Cohen L. 2011. Biphenyl and ethylbenzene dioxygenases of *Rhodococcus jostii* RHA1 Transform PBDEs. *Biotechnol Bioeng* 108:313–321. [http://dx.doi.org/10.1002/bit.22952](https://doi.org/10.1002/bit.22952).
- Peng X, Taki H, Komukai S, Sekine M, Kanoh K, Kasai H, Choi SK, Omata S, Tanikawa S, Harayama S, Misawa N. 2006. Characterization of four *Rhodococcus* alcohol dehydrogenase genes responsible for the oxidation of aromatic alcohols. *Appl Microbiol Biotechnol* 71:824–832. [http://dx.doi.org/10.1007/s00253-005-0204-6](https://doi.org/10.1007/s00253-005-0204-6).
- Holder JW, Ulrich JC, DeBono AC, Godfrey PA, Desjardins CA, Zucker J, Zeng Q, Leach AL, Ghiviriga I, Dancel C, Abeel T, Gevers D, Kodira CD, Desany B, Affourtit JP, Birren BW, Sinskey AJ. 2011. Comparative and functional genomics of *Rhodococcus opacus* PD630 for biofuels development. *PLoS Genet* 7:e1002219. [http://dx.doi.org/10.1371/journal.p-gen.1002219](https://doi.org/10.1371/journal.p-gen.1002219).
- Letek M, González P, Macarthur I, Rodríguez H, Freeman TC, Valero-Rello A, Blanco M, Buckley T, Cherevach I, Fahey R, Hapeshi A,

- Holdstock J, Leadon D, Navas J, Ocampo A, Quail MA, Sanders M, Scortti MM, Prescott JF, Fogarty U, Meijer WG, Parkhill J, Bentley SD, Vazquez-Boland JA. 2010. The genome of a pathogenic *Rhodococcus*: cooptive virulence underpinned by key gene acquisitions. *PLoS Genet* 6:e1001145. <http://dx.doi.org/10.1371/journal.pgen.1001145>.
9. Meijer WG, Prescott JF. 2004. *Rhodococcus equi*. *Vet Res* 35:383–396. <http://dx.doi.org/10.1051/vetres:2004024>.
 10. Muller C, Birmes FS, Niewerth H, Fetzner S. 2014. Conversion of the *Pseudomonas aeruginosa* quinolone signal (PQS) and related alkylhydroxyquinolines by *Rhodococcus* sp. strain BG43. *Appl Environ Microbiol*.
 11. Jauregui R, Rodelas B, Geffers R, Boon N, Pieper DH, Vilchez-Vargas R. 2014. Draft genome sequence of the naphthalene degrader *Herbaspirillum* sp. strain RV1423. *Genome Announc* 2(2):e00188–14. <http://dx.doi.org/10.1128/genomeA.00188-14>.
 12. Kabelitz N, Machackova J, Imfeld G, Brennerova M, Pieper DH, Heipieper HJ, Junca H. 2009. Enhancement of the microbial community biomass and diversity during air sparging bioremediation of a soil highly contaminated with kerosene and BTEX. *Appl Microbiol Biotechnol* 82: 565–577. <http://dx.doi.org/10.1007/s00253-009-1868-0>.
 13. Vilchez-Vargas R, Geffers R, Suárez-Diez M, Conte I, Waliczek A, Kaser VS, Kralova M, Junca H, Pieper DH. 2013. Analysis of the microbial gene landscape and transcriptome for aromatic pollutants and alkane degradation using a novel internally calibrated microarray system. *Environ Microbiol* 15: 1016–1039. <http://dx.doi.org/10.1111/j.1462-2920.2012.02752.x>.
 14. Hernandez D, François P, Farinelli L, Østerås M, Schrenzel J. 2008. *De novo* bacterial genome sequencing: millions of very short reads assembled on a desktop computer. *Genome Res* 18:802–809. <http://dx.doi.org/10.1101/gr.072033.107>.
 15. Hernandez D, Tewhey R, Veyrieras JB, Farinelli L, Østerås M, François P, Schrenzel J. 2014. *De novo* finished 2.8 Mbp *Staphylococcus aureus* genome assembly from 100 bp short and long range paired-end reads. *Bioinformatics* 30:40–49. <http://dx.doi.org/10.1093/bioinformatics/btt590>.
 16. Aziz RK, Bartels D, Best AA, DeJongh M, Disz T, Edwards RA, Formsma K, Gerdes S, Glass EM, Kubal M, Meyer F, Olsen GJ, Olson R, Osterman AL, Overbeek RA, McNeil LK, Paarmann D, Paczian T, Parrello B, Pusch GD, Reich C, Stevens R, Vassieva O, Vonstein V, Wilke A, Zagnitko O. 2008. The RAST server: Rapid Annotations using Subsystems Technology. *BMC Genomics* 9:75. <http://dx.doi.org/10.1186/1471-2164-9-75>.
 17. Yoo M, Kim D, Choi KY, Chae JC, Zylstra GJ, Kim E. 2012. Draft genome sequence and comparative analysis of the superb aromatic-hydrocarbon degrader *Rhodococcus* sp. strain DK17. *J Bacteriol* 194:4440. <http://dx.doi.org/10.1128/JB.00844-12>.
 18. Brooks SL, Van Hamme JD. 2012. Whole-genome shotgun sequence of *Rhodococcus* species strain JVH1. *J Bacteriol* 194:5492–5493. <http://dx.doi.org/10.1128/JB.01066-12>.
 19. McLeod MP, Warren RL, Hsiao WW, Araki N, Myhre M, Fernandes C, Miyazawa D, Wong W, Lillquist AL, Wang D, Dosanjh M, Hara H, Petrescu A, Morin RD, Yang G, Stott JM, Schein JE, Shin H, Smailus D, Siddiqui AS, Marra MA, Jones SJ, Holt R, Brinkman FS, Miyauchi K, Fukuda M, Davies JE, Mohn WW, Eltis LD. 2006. The complete genome of *Rhodococcus* sp. RHA1 provides insights into a catabolic powerhouse. *Proc Natl Acad Sci USA* 103:15582–15587. <http://dx.doi.org/10.1073/pnas.0607048103>.
 20. Sekine M, Tanikawa S, Omata S, Saito M, Fujisawa T, Tsukatani N, Tajima T, Sekigawa T, Kosugi H, Matsuo Y, Nishiko R, Imamura K, Ito M, Narita H, Tago S, Fujita N, Harayama S. 2006. Sequence analysis of three plasmids harboured in *Rhodococcus erythropolis* strain PR4. *Environ Microbiol* 8:334–346. <http://dx.doi.org/10.1111/j.1462-2920.2005.00899.x>.
 21. Strnad H, Patek M, Fousek J, Szokol J, Ulbrich P, Nesvera J, Paces V, Vlcek C. 2014. Genome sequence of *Rhodococcus erythropolis* strain CCM2595, a phenol derivative-degrading bacterium. *Genome Announc* 2(2):e00208–14. <http://dx.doi.org/10.1128/genomeA.00208-14>.
 22. Kwasiborski A, Mondy S, Beury-Cirou A, Faure D. 2014. Genome sequence of the quorum-quenching *Rhodococcus erythropolis* strain R138. *Genome Announc* 2(2):e00224–14. <http://dx.doi.org/10.1128/genomeA.00224-14>.
 23. Dueholm MS, Albertsen M, D'Imperio S, Tale VP, Lewis D, Nielsen PH, Nielsen JL. 2014. Complete genome of *Rhodococcus pyridinivorans* SB3094, a methyl-ethyl-ketone-degrading bacterium used for bioaugmentation. *Genome Announc* 2(3):e00525–14. <http://dx.doi.org/10.1128/genomeA.00525-14>.
 24. Sun JQ, Xu L, Wang LJ, Wu XL. 2015. Draft genome sequence of a *Rhodococcus* strain isolated from tannery wastewater treatment sludge. *Genome Announc* 3(1):e01463–14. <http://dx.doi.org/10.1128/genomeA.01463-14>.